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OPTIMIZING INDIRECT COSTS ON MACHINING CENTRES BY THE MHR METHOD

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Abstract:
The planning, tracing and controlling of production costs represents the essence of enterprise management, especially for those which bring added value, this process being also known as “cost management”.
Contextualizing the general tasks of the management with the phenomenon of intensification of general imbalances (of the fundamental equation in economy R < N) which tends to be ever more difficult to solve, the major aim will be to ensure an elevated level of sustainability of the activities carried out.
One of the solutions of the above equation can be provided by the mechanism of planning production costs, which should be adapted to the performance requirements. In what way?
a) researching the technical-economic behaviour of the basic links within the enterprise, namely Machining Centres (CNC);
b) determining the degree of exploitation of production capacities;
c) optimizing the exploitation of CNC in relation to indirect costs.
Researching production cost within a CNC, especially of indirect costs, can be theoretical or pragmatic in nature. The approach of this topic aims at the pragmatic side of research, when explanations and improvements are brought to the mechanisms of planning production costs, and one can offer solutions and suggestions on how to solve certain current issues.
The objective of the current paper is to obtain an optimal relation during the planning stage of the production cost within a Processing Centre by applying the calculation technique Machine-Hour-Rates (MHR).

Keywords: planning, MHR calculation method, costs optimization, efficiency.

1. CHARACTERISTICS OF THE MACHINING CENTRE (CNC)

The CNC is defined as "a machine-tool with numerical control, with tool post and transfer mechanism, which can automatically perform a switch of tools between the tool post and the main axle".
Technically speaking, the CNC has:

a) *advantages* about: the limitation of the operator's intervention in supplying the necessary tools; the possibility to perform a very large number of operations in just one move; the limitation of auxiliary times; the increase of the load and intensive usage of the machine etc.
b) *disadvantages* about: longer extent of time for fitting, positioning, orienting and securing parts; the need to stop the machine to secure tools, parts and devices; unsatisfactory productivity (Vișan & Ionescu, 2014).

From the perspective of cost calculation, CNC are treated as Responsibility Centres (RC) – generic concept which suggests the segmentation of economic activities into functional components – which can be planned (budgeted) and traced distinctively.
If one relates the shortcomings of the CNC to the production costs, one can state that there exists a conditioning link between:

a) the pause time and elements of indirect consumption (energy, consumables, maintenance etc.);
b) the pause time and technical efficiency, work productivity, efficiency etc.

The determination of the exploitation regime of a CNC is done under the conditions of admitting a determinant criterion such as:

a) minimal cost,
b) maximum productivity.

Due to technical-economical and financial reasons, the criterion most often used is the one which envisages cost optimization.
Obtaining the optimal cost criterion requires the existence of an adequate exploitation regime, a situation where general productivity will record the same trend.
The essential element in setting the parameters for the exploitation regime is represented by the technical characteristics of the CNC.

$$\rho = \frac{1-m}{m}\left(t_s + \frac{a}{C_{\exp l}}\right) \quad (1)$$

and

$$C_{\exp l} = t_i * a \quad (2)$$

where:

ρ – exploitation parameter,
m – exploitation exponent, experimentally determined,
ts – pause time,
a – hourly rate for workers,
Cexpl – exploitation cost of the CNC,
ti – calculated pause time, determined through measurements depending on the operations which need to be carried out.

Observing the convergence between the exploitation regime (pause time) on the one hand, and the resource consumption, efficiency and productivity on the other hand, the starting point of the research will be this relation, with the intention to identify an optimal level of the exploitation regime in such a way that controllable consumption is minimal.

2. ABOUT PRODUCTION COSTS

The seeds of superior performance and efficiency in enterprises can usually be found during the planning stage of production costs and will generate effects on the overall activity. The requirements for cost planning overlap the desiderates of management, touching upon aspects such as: economy (improvement of the consumption of resources), financial (variation of profit margin), competition (consolidating one's position on the specific marketplace) as well as substantiating decisions regarding the organization and exploitation of the production capacity (Popa, 2005).
Regardless of the calculation method employed, production costs require an approach of the resources involved in the economic processes from the point of view of the two major components of the

management of an enterprise: planning and cost control; these components make up the piloting process of economic activities through costs (Dutescu, 2003).
Productive enterprises have two types of costs:

a) *direct* (variable) – those calculation items which can be identified on the calculation object (product, service, work, phase, activity, function etc.), since the planning stage, carrying out of consumption and post calculation analysis. The following are included in this category: raw materials and direct materials, energy consumed for technological purposes, direct manpower etc. Direct costs are characterized by fluctuations which are proportional to the evolution of the production volume (Q).
b) *indirect* – refer to those consumptions or expenses which are not clearly or directly identified on the calculation object. Usually indirect costs are in relation to the activity that is adjacent to the basic economic process, being necessary and often indispensable. Indirect consumptions are also called fixed expenses or overheads and are relatively constant in relation to the fluctuation of the production volume (Q). When the calculation of the cost is part of a rigorous process with the activity of the management, overheads are and can be analysed on two different segments: variable and fixed (Popa, 2005)
   b.1. variable overhead - their support is indirect consumptions of materials or manpower, in relation to the object of calculation, and cannot be found directly in the manufactured product. Material or indirect manpower consumption are linked to the production volume (Q), recording fluctuations like the modification of Q.
   b.2. fixed overheads – are constant, regardless of the variation in production volume (amortization of machinery and equipment, maintenance of departments and machinery, administrative costs of departments or general ones).

Expenses which are part of indirect costs will be found in the calculation object only after their distribution. Distribution techniques consider the particularities of economic processes, organizational segmentation, or budget mechanisms, and are the result of managerial decisions. Practically, the distribution process shall be appropriate for the calculation methods used and the production activity (Dumbravă *et al.*, 2000).
The calculation methods of costs are quite diverse. One of these is the Machine-Hour-Rate method which is usually applied in Responsibility Centres whose subject is the machine, the group of machines or the work installations, in accordance with the labour, i.e. what characterizes this method.

3. THE MHR CALCULATION METHOD

To obtain the expected results, the machine or the processing centre shall be considered fundamental economic units (FEU) or Responsibility Centres in Production (RCP) within which attention is focused upon the exploitation regime of the production capacity:

a) *Machine-hour-rate* (MHR) – obtained through adding direct and indirect costs incurred by the processing of a product under a certain time span, usually one hour (h), such as: material costs for exploitation and processing (energy, maintenance, direct amortization, consumables etc.) to which one adds manpower expenses of the personnel directly involved in the exploitation of RCP.
b) *Material cost per product unit* – is given by the purchase price (for evaluation and registration) of raw materials, and direct and indirect materials.

The calculation relation for the MHR method is the following:

$$Ct = (THM * t) + Chm \tag{3}$$

where:
Ct – total processing cost,
THM (MHR) –machine-hour-rate,
t – work time,
Chm – cost of materials,

and

$$THM = \sum_{i=1}^{n} \left[\frac{Chd}{t} + \frac{Chid}{t} \right] \tag{4}$$

where:
Ch – direct and indirect processing expenses

t – processing time in hours.
The unit cost per calculation object is based on the:

- processing cost, for the process, the work or service,
- raw materials and direct materials.

The processing cost in relation to the time required to go through the entire processing process during a FEU is determined by applying the following relation:

$$Cpr = \sum_{i=1}^{n} t * THM \tag{5}$$

The cost of raw materials and direct materials is determined using the method of balancing quantities with prices.
Thus, the cost per product unit can be calculated using the formula:

$$Cu = \frac{\sum_{i=1}^{n} (t * THM) + Chm}{Q} \tag{6}$$

where:
Cu – cost of product unit,
Chm – cost of raw materials and other materials,
Q – manufactured quantity.
When calculating production cost based on a CNC, the interest focuses on obtaining an optimal cost based on the application of the MHR calculation method.

4. PROCEDURE FOR OPTIMIZING PRODUCTION COST IN RELATION TO PROCESSING TIME

Since an enterprise has a certain amount of time to deliver the products (Q), which will be produced by a certain PS, then in accordance with this factor, the following question is asked:
What is the optimal level at which a CNC should be exploited to meet the deadline and, consequently, obtain a minimum production cost?
The time required for manufacturing a product is somewhere between the minimum time required for the production (dependent on the technical characteristics of the machine) and the maximum value given by the deadline at which products must be delivered.

$$t_{fbr} \in [t_{\min}, t_{\max}] \tag{7}$$

$$t_{\max} = \frac{t_t}{Q} \tag{8}$$

To determine the optimal time which will be established for finishing a product Q, *a detailing of the components of the unit cost* is necessary, thus:

1. *direct salary costs* are dependent on the manufacturing time, directly proportional with an hourly rate *lei/h* established a priori (a);

The dependence of salaries on the time factor is considered a function which can be written as follows:

$$f1(t) = t * a \tag{9}$$

2. *expenses with productive energy, with consumables and daily repairs/machine* (b) expressed in *lei/h*, depend in inverse proportion on the degree of usage of the CNC, i.e. at a more intense use of the machinery, the level of repairs increases exponentially.

This connection can be expressed by means of the second function, namely f2, where *c* represents the coefficient of exponential increase:

$$f2(t) = b/t^c \quad (10)$$

3. *the power used during planned or unplanned pauses*, will depend on the time span required of obtain a product (lei/h) and will be marked with *d*, and it can be expressed by means of function f3 below:

$$f3(t) = t * d \quad (11)$$

4. *amortization and expenses with administration salaries (e=lei/day)* do not depend on the production volume for one day, but will be divided depending on the products manufactured within the time frame of the workday, and can be expressed in relation f4 below:

$$f_4(t) = e * \frac{\frac{i}{t}}{q + \frac{i}{t}} = e * \frac{i}{q * t + i} \quad (12)$$

where:
i – time frame within a workday (usually equal to eight),
q - quantity of other products than the product under research.

The total production cost, by means of the MHR calculation method, represent a summative factor of the above 4 functions; thus:

$$Ct = f(t) = f1(t) + f2(t) + f3(t) + f4(t) \quad (13)$$

If we derive f(t) and equal the derivative with zero, we will obtain the extreme points of the evolution of costs based on the manufacturing time.
Considering that one single CNC produces a single type of products, then function f4 will be constant in relation to (t) and its derivative will equal zero.
Under these circumstances, f(t) will be:

$$f(t) = a*t + b/t^c + d*t \quad (14)$$

$$f'(t) = a - b*c/t^{c+1} + d \quad (15)$$

$$t = \sqrt[c+1]{\frac{b*c}{a+d}} \quad (16)$$

where:
a = rate/h,
b = cost of consumables and daily repairs,
c = parameter of exponential growth of the employment level of the CNC,
d = cost of non-productive energy, consumed during pauses.
The answer to the objective of the research topic is relation (14) above, which suggests *a calculation procedure of the optimal level of exploitation of a CNC in relation to indirect costs incurred by pauses*.
By adding indirect costs with direct cost, the total cost of the production within a specific time span, with all the influence upon the profit margin, is obtained.

5. VERIFICATION OF THE THEORETICAL STATEMENTS ON THE PROCEDURE OF OPTIMIZING PRODUCTION COSTS BY MEANS OF THE MHR METHOD

The suggested procedure, namely relation (14) above, is verified within a processing enterprise through the optimization of manufacturing times when restricted by delivery deadlines:

- ✓ the minimum time for manufacturing product named X, through a use of the CNC at maximum capacity, is 2 h;
- ✓ the total production (Q) which need to be done is 15 pieces;
- ✓ the deadline by which production needs to be finished is 13 working days, 8 h/day, which means that, for a product one can allot maximum 7 h;
- ✓ the worker's rate (a) is 12 lei/h;
- ✓ at an extensive employment of the CNC (the lowest degree of using the production capacity), to manufacture a product in 7h, the value of consumables and repairs will be 10 lei/piece. This value increases exponentially with the reduction of the manufacturing time allotted for a product with a coefficient c=2. The increase of costs with consumables is an effect of the wear of the CNC, since, as mentioned before, the cost of consumables and daily repairs depends on the intensity of the employment of the CNC and the production volume obtained within a certain time span;
- ✓ depending on the extent of employment of the CNC, and by considering the deadline when used extensively for 7h, the level of indirect consumption is 10 lei/piece = b/7c, resulting a value of b=490;
- ✓ considering the rate for the power consumed during the pauses in the use of the machinery at 3 lei/h, then the function becomes:

$$f(t) = a*t + b/tc+d*t = 12*t + 490/t2+3*t$$

followed by the derivative:

$$f'(t) = 15 - 490*2/t2+1$$

If we equal the derivative with zero, then the level of *t* will be:

$$t = \sqrt[3]{\frac{980}{15}} = \sqrt[3]{65,3333} \cong 4$$

with an optimal 4 h/day/piece, level situated between the minimum and the maximum amount of time, namely between 2 h/day/piece and 7 h/day/piece.

CONCLUSIONS

- Restrictions in application:

The method of calculation of the optimal exploitation time of a Machining Centre in relation to indirect costs obtained herein has limited applicability, i.e. at the level of Responsibility Centres whose subject is the machinery, the group of machines or the work installation.

- Accuracy:

Regarded as an extension of the process of planning production costs, using the MHR calculation method, the calculation procedures offer the management a viable, practical and efficient solution about the degree to which one should use production capacities (CNC), depending also on reaching an optimal level of indirect costs.

- Continuity:

This research theme can be extended to the practical application of other calculation methods of costs such as standard costing and direct costing. It is worth mentioning the fact that, when dealing with these methods, the optimal function should be obtained based on the keys of distributing overheads and not the manufacturing time.

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